Sandia National Laboratories

PROPOSAL FOR ADMINISTRATIVE NO FURTHER ACTION ENVIRONMENTAL RESTORATION SITE 43, RADIOACTIVE MATERIAL STORAGE YARD (TA-II)(ACTIVE) OPERABLE UNIT 1303

August 1994

Environmental
Restoration
Project

United States Department of Energy
Albuquerque Operations Office

PROPOSAL FOR ADMINISTRATIVE NO FURTHER ACTION

SITE 43, Radioactive Material Storage Yard (TA-II)
OU 1303

SANDIA NATIONAL LABORATORIES/NEW MEXICO

1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing an administrative No Further Action (NFA) decision for Environmental Restoration (ER) Site 43, Radioactive Materials Storage Yard (RMSY) Technical Area (TA)-II, Operable Unit (OU) 1303.

The site was established around 1959 and was operated by the Health Physics Division. The Radioactive and Mixed Waste Department took over management in 1989. It has been designated as a Radioactive Materials Management Area.

2.0 HISTORY OF UNIT

The low-level RMSY, designated as Solid Waste Management Unit (SWMU) #57 in the RCRA Facilities Assessment (RFA 1987), is located on the west side of TA-II (Attachment 1). It is approximately 50 feet in width by 100 feet in length. In 1970 a chain-link fence was installed with a locked gate surrounding the area and radioactive warning signs were posted.

The RMSY has been used during the last 33 years (from about 1961 to 1994) for temporary storage of small, sealed radioactive sources of 10 to 20 millicuries. However, nothing has been placed in the area since 1990 and the few remaining items will be removed by the end of fiscal year 1994. The sources stored at the RMSY were purchased by various SNL/NM organizations for research and experimental purposes. When the sources were no longer required by these organizations, they were temporarily stored at the RMSY before being disposed of.

Cobalt 60 and cesium 137 have been the primary radioactive sources stored at the RMSY. Other radioactive sources, including tritium and uranium, also have been stored at the site. The sources were placed in various sized lead casks with one-inch-thick walls. Depending on their size, one or more casks were subsequently placed into 250-cubic-feet transportainers in preparation for disposal. After holding a source for one year, casks were placed into larger containers and covered (sealed or encapsulated) with concrete. The concrete-filled containers then were disposed of in the Mixed Waste Landfill (MWL), located in TA-III. Empty casks previously used in various work areas to store slightly activated materials also were stored temporarily on pallets at the RMSY. Site 43 also reportedly was used as a temporary holding area for radioactively contaminated material such as cabinets, fume hoods, laboratory benches, desks, and trailers until they could be disposed in the MWL. Constituents of Potential Concern (COPC) which may have been released should be limited to surface and near-surface soil in the immediate vicinity of the RMSY since all storage activities occurred within the fenced area on wooden pallets.

3.0 EVALUATION OF RELEVANT EVIDENCE

Information collected during the Comprehensive Environmental Assessment and Response Program (CEARP) indicated that surplus radioactively contaminated equipment was stored on a fenced concrete pad in Area II (Site 43) with no provision made for collecting the runoff from the pad (DOE 1987). A concrete pad does not exist at the site. All sources are kept on wooden pallets which minimizes the potential for contamination.

In September 1991, two surface soil samples were collected between 0 and 0.5 feet deep, and analyzed for tritium and total uranium. Gamma spectrometry also was performed on the surface soil samples. The sample taken from near the southeast corner of the storage yard contained tritium at 2,300 pCi/ml (soil moisture) and total uranium at 16 μg/g.

In November 1993, surface and near-surface soil samples were collected from the RMSY as part of National Emissions Standards for Hazardous Air Pollutants (NESHAPs) sampling. Seventeen grab samples were collected from the surface at zero to two inches, and three soil samples were collected from two to three feet deep with a hand-auger. Attachment 1 shows the locations of soil samples collected at the RMSY. All soil samples were analyzed for gross alpha and gross beta, plutonium, total tritium, total uranium, other radioisotopes, and metals.

Based on the analytical results from sampling of the area, Site 43 was proposed for voluntary corrective action to ensure that no conceivable risk to human health was present. First, however, a preliminary risk assessment was conducted to evaluate if any potential risks to human health exist at the site (Attachment 2). Dose rates from the radionuclide COPC and risks from the chemical COPC were calculated for the residential and industrial scenarios. The following conservative assumptions were used for the evaluation of the residential scenario:

- The individual establishes a residence at the evaluated site,
- The individual consumes drinking water from a well drilled directly through the evaluated waste site,
- The individual consumes vegetable and fruit products grown in the soils at the evaluated waste site, and
- The individual consumes meat and dairy products from animals which have been exposed to forage and ground water produced at the evaluated waste site.

The following assumptions were used for the evaluation of the industrial scenario:

- The individual works at the evaluated site only,
- The individual does not mitigate his potential exposures by avoiding contaminant contact or using personal protective equipment (i.e., individual is unaware of the existence of hazards), and
- The individual consumes drinking water from a well drilled directly through the evaluated waste site.

These estimates represent upper bounds of the potential threat to human health from the COPC detected at the RMSY.

Calculated radionuclide dose rates are below the SNL/NM 10 mrem/yr dose rate action level which is in accordance with (DOE) Order 5820.2A "Radioactive Waste Management".

Agency (EPA) techniques described in "Risk Assessment Guidance for Superfund" and the results were compared with the maximum human health risk levels historically regarded as acceptable by EPA (SNL, 1994). Although analytical results were higher than background, they do not result in calculated risks above the acceptable risk level of 1×10^{-6}.

During the month of April 1994, seven additional soil samples were collected as follow-up to the November NESHAPs sampling activity. Six surface soil and one shallow subsurface soil sample were collected and analyzed for isotopic plutonium and other radioisotopes. None of the additional sample results exceeded previous results which were incorporated into the risk calculations.

4.0 CONCLUSION

A Human Health Risk Assessment was conducted to evaluate whether any potential hazard exists at Site 43. Based on the following information:

- annual dose rates are not expected to exceed 10 mrem/yr within the next 500 years from RMSY radionuclide COPC in the residential and industrial scenarios,

- lifetime incremental cancer risks (ICR) from RMSY chemical COPC were found not to exceed 1×10^{-6} in the residential and industrial scenarios. ICR less than 1×10^{-6} have been historically regarded as acceptable by the EPA, and

- The RMSY site Hazard Index was found not to exceed the adverse human health effects threshold in the residential and industrial scenario.

Site 43 is being proposed for an NFA determination.

5.0 REFERENCES

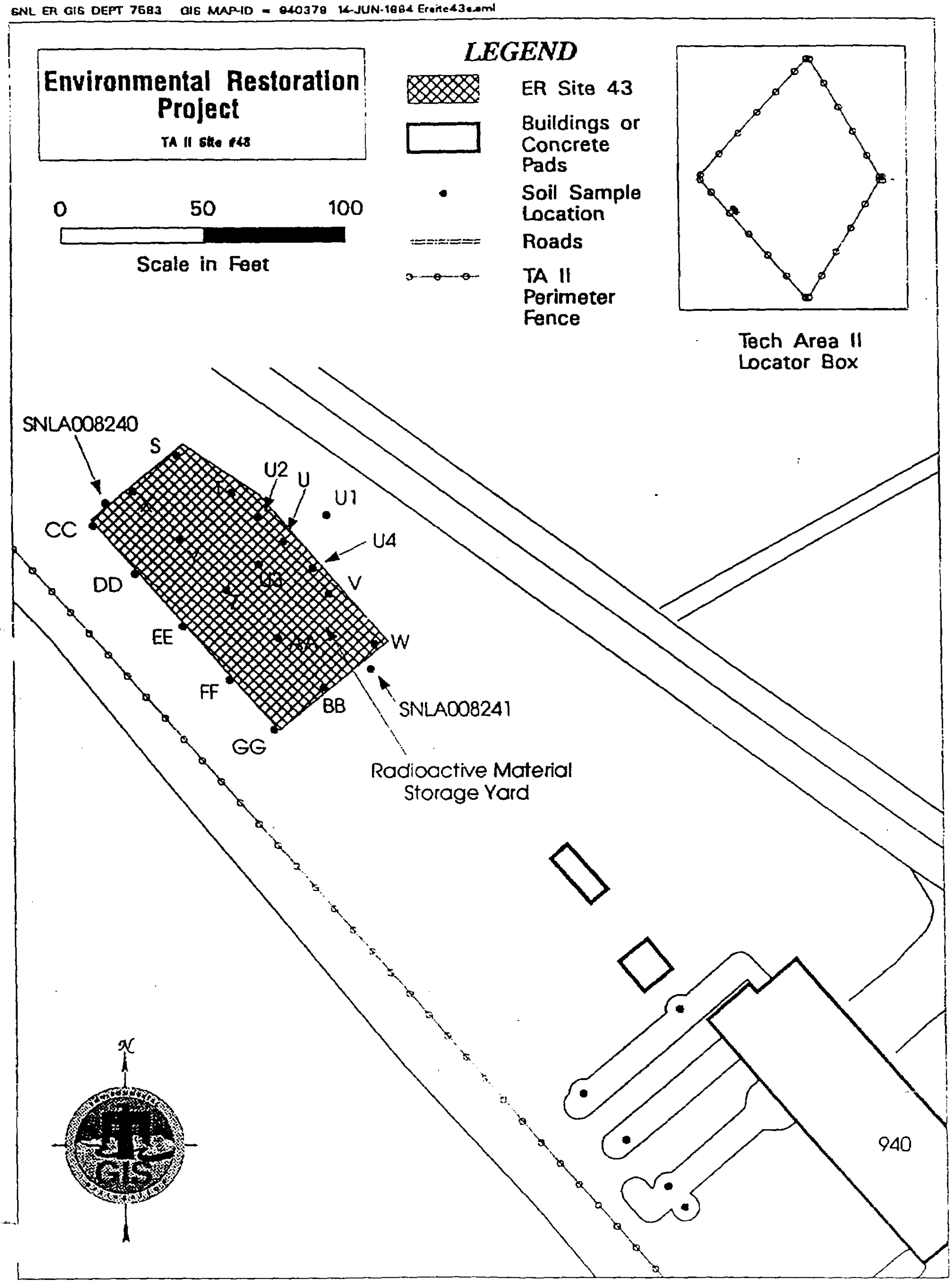
Sandia National Laboratories (SNL, 1994), "Radioactive Material Storage Yard, Environmental Restoration Site #43, Human Health Risk Assessment," May 1994.

U.S. Department of Energy (DOE 1987), "Draft Comprehensive Environmental Assessment and Response Program (CEARP) Phase 1: Installation Assessment," September 1987.

6.0 LIST OF ATTACHMENTS

Attachment 1
Map showing the location of the Radioactive Material Storage Yard Technical Area II, SNL/NM

Attachment 2
Radioactive Material Storage Yard Environmental Restoration Site #43, Human Health Risk Assessment



Map showing the location of the Radioactive Material Storage Yard Technical Area II, SNL/NM.

ATTACHMENT 2

RADIOACTIVE MATERIAL STORAGE YARD, ENVIRONMENTAL RESTORATION SITE #43, HUMAN HEALTH RISK ASSESSMENT

Prepared for:

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1.0 Introduction

1.1 Project Background

Sandia National Laboratories (SNL/NM) located in Albuquerque, New Mexico, is committed to the protection of human health and the environment. The Radioactive Material Storage Yard (RMSY), Environmental Restoration (ER) Site #43, Human Health Risk Assessment (HRA) evaluates the potential risks to human health from the contaminants of potential concern (COPC) detected in RMSY soil samples in a manner consistent with this commitment.

Twenty soil samples were collected and analyzed for potential radionuclide and inorganic metal contaminants. Representative RMSY soil concentrations of the detected analytes were compared to draft SNL/NM background values to determine the COPC. Dose rates from the radionuclide COPC and risks from the chemical COPC were calculated for the residential and industrial scenarios. These estimates represent upper bounds of the potential detriment to human health from the COPC detected at the RMSY.

Annual dose rates resulting from the radionuclide COPC are estimated using the SNL/NM Précis computer program. The radionuclide COPC HRA results are compared with the SNL/NM 10 mrem/yr dose rate action level which complies with the Department of Energy (DOE) Order 5820.2A "Radioactive Waste Management" performance objective of a 25 mrem/yr dose rate limit to any member of the public (DOE 1988).

Potential lifetime incremental cancer risks (ICR) and systemic toxicant effects resulting from the chemical COPC are estimated using standard Environmental Protection Agency (EPA) techniques described in "Risk Assessment Guidance for Superfund" (RAGS, EPA 1989). The chemical COPC HRA results are compared with the maximum human health risk levels historically regarded as acceptable by the EPA.

2.0 Site Characterization

2.1 Site Description

The low-level RMSY, ER Site 43, consists of a fenced area approximately 50 ft wide by 100 ft long located within SNL/NM Technical Area II (TA-2), Kirtland Air Force Base (KAFB)

(Figure 2-1). Starting in 1961, the RMSY has been used as a temporary storage area for small, sealed radioactive sources. These activities continue at the RMSY and the site is designated as a Radioactive Materials Management Area (RMMA).

Cobalt-60 and cesium-137 have been the primary encapsulated radioactive sources stored at the RMSY, with activities ranging between 10 to 20 milliCuries (SNL, 1992). Other radioactive sources, including tritium (hydrogen-3) and uranium, have also been stored at this site over its 33 year operational history. The sources were placed in lead casks, which were comprised of 1 inch thick lead bricks, which were subsequently placed in 250 ft^3 transportainers and held in storage for a maximum of one year. The storage casks were ultimately sealed and/or encapsulated with concrete and sent to the Mixed Waste Landfill for disposal. The RMSY was also used as a temporary holding area for contaminated materials such as cabinets, fume hoods, laboratory benches, etc. No written records are available concerning the types and quantities of COPC stored at the RMSY (SNL, 1992).

2.2 Contamination Assessment

In November 1993, seventeen surface (0 to 2 inches below soil surface) and three near-surface (2 to 3 feet below soil surface) soil samples were collected from the RMSY. Soil concentrations of potential radionuclide and metal contaminants were assayed using gross alpha, gross beta, isotopic plutonium, tritium, total uranium, gamma spectroscopy, and Target Analyte List (TAL) metals analytical techniques. Appendix A summarizes the results of this investigation.

Soil concentrations of tritium (hydrogen-3) were converted from the reported activity per milliliter of soil moisture to activity per gram of soil by assuming a water density of 1 g/cm^3 and using the soil moisture values reported by the analytical laboratory. Progeny of the natural decay series detected at the RMSY (e.g., uranium-238 series and thorium-232 series), were assumed to be in equilibrium with their respective parent radionuclides. The uranium series soil concentration was approximated using the total uranium soil concentration values obtained by fluorometric analyses and by assuming that all of the detected uranium was the uranium-238 isotope. The thorium series soil concentration was based on the concentration of the immediate thorium-232 daughter, actinium-228. Radium-226 soil concentrations, a member of the uranium decay series, were also evaluated because this radionuclide can be used as a calibration source and, although there is no record of it, may have been stored at the RMSY.

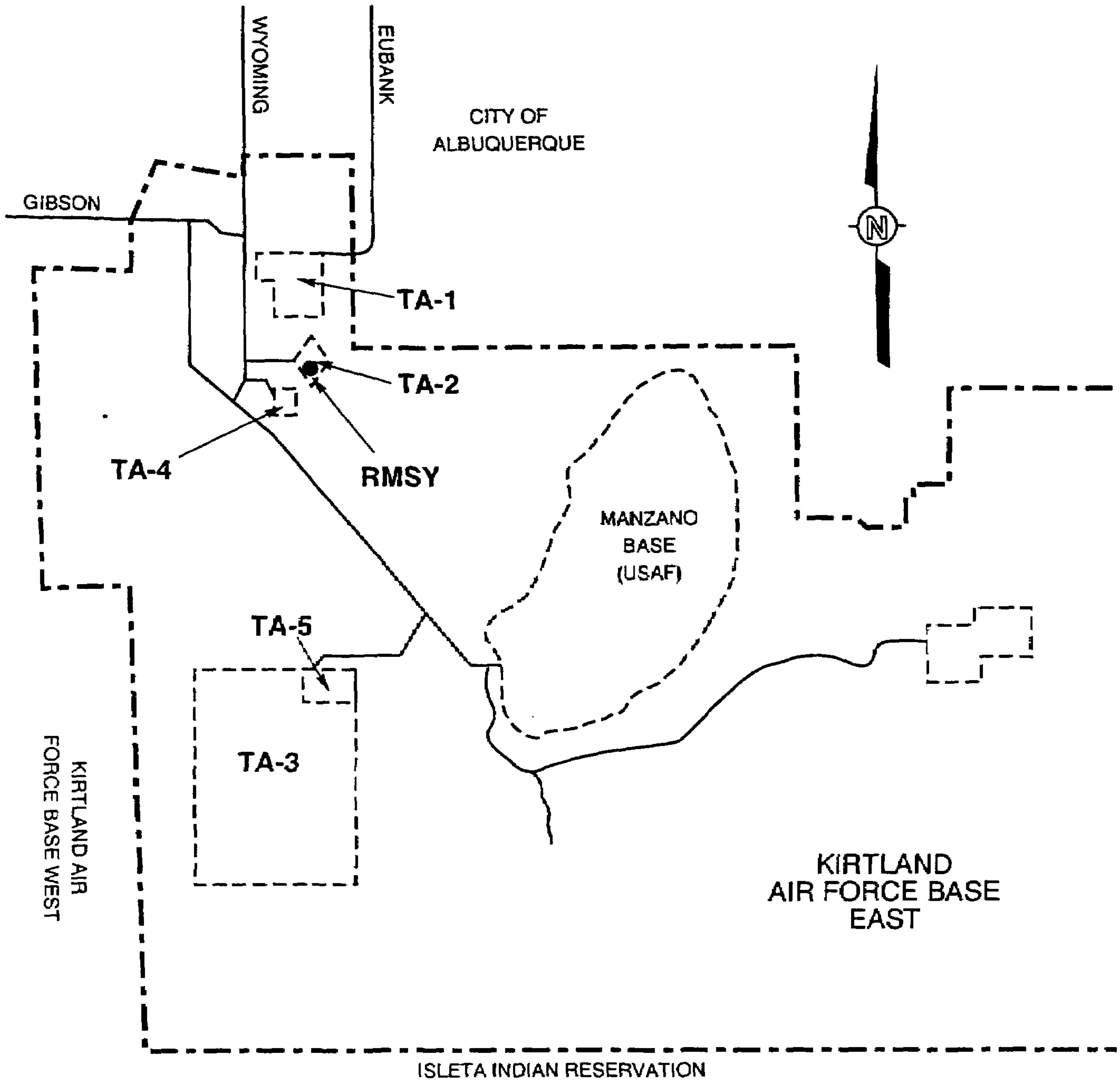


Figure 2-1

Location of Sandia National Laboratories Radioactive Materials Storage Yard (RMSY), ER Site #43

The W Test, which tests the null hypothesis that the distribution is normal, was performed on all analyte data sets to determine the goodness-of-fit of the data set with normal and lognormal distributions (Gilbert 1987). Censored data sets (i.e., data sets containing "nondetect" [ND] values) were evaluated by replacing NDs with one half the detection limit values. Table 2-1 contains the distribution types of the COPC data sets as determined at the 95% significance level. It should be noted that values in Table 2-1 are reported to one digit greater than significant. This was done to decrease the effects of rounding errors in subsequent calculations.

The distribution type (i.e., normal versus lognormal) of several RMSY analyte data sets could not be resolved at the 95% significance level by the W Test. This effect was particularly noted in heavily censored data sets which were comprised of ND values and a distribution of detected values. Because large or "complete" environmental contaminant data sets from soil sampling are often found to be lognormally distributed, analyte distribution types which could not be resolved at the 95% significance level were assumed to be lognormal (EPA 1992a).

The 95% upper confidence limit (UCL) of the arithmetic mean of each analyte data set was used as the representative analyte soil concentrations at the RMSY (EPA 1992a). For normally distributed analyte data sets, this value was calculated as:

$$UCL_{95\%} = \mu + t_{95\%} \cdot (s/n^{1/2})$$

where:

$UCL_{95\%}$	=	upper confidence limit of the mean at the 95% significance level
μ	=	arithmetic mean of the data set
$t_{95\%}$	=	student-t statistic at the 95% percent significance level for n-1 samples (Gilbert, 1987)
s	=	standard deviation of the data set
n	=	number of sample

Table 2-1
Contaminants of Potential Concern (COPC) Screening Process
SNL/NM Radioactive Materials Storage Yard (RMSY), ER Site 43

Detected Chemical Analyte	95% Significance Distribution Type	Upper 95th Confidence Level Mean Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg)	Detected Analyte Status
Aluminum	Lognormal	11,000	ND	Analyte considered nontoxic to humans
Barium	Lognormal	103	398.1	Analyte concentration is consistent with the background distribution
Beryllium	Lognormal[a]	0.3	0.785	Analyte concentration is consistent with the background distribution
Cadmium	Lognormal[a]	0.6	3.51	Analyte concentration is consistent with the background distribution
Calcium	Lognormal[b]	34,000	ND	Analyte considered nontoxic to humans
Chromium	Lognormal[c]	28	22.90	COPC[d]
Cobalt	Lognormal[b]	5.1	ND	COPC
Copper	Lognormal[b]	14.7	16.74	Analyte concentration is consistent with the background distribution
Iron	Lognormal	15,000	ND	Analyte considered nontoxic to humans
Lead	Lognormal[b]	34	15.0	COPC
Magnesium	Lognormal[b]	3,400	ND	Analyte considered nontoxic to humans
Manganese	Lognormal[c]	230	ND	COPC
Nickel	Lognormal	9	15.39	Analyte concentration is consistent with the background distribution
Potassium	Lognormal	2,500	ND	Analyte considered nontoxic to humans
Sodium	Lognormal[b]	210	ND	Analyte considered nontoxic to humans
Strontium	Lognormal[b]	52	ND	COPC
Titanium	Lognormal[b]	690	ND	COPC
Uranium (Total)	Lognormal[c]	1.7	3.5	Analyte concentration is consistent with the background distribution
Vanadium	Lognormal	32	ND	COPC

Refer to footnotes at end of table.

Table 2-1 *(Continued)*
Contaminants of Potential Concern (COPC) Screening Process
SNL/NM Radioactive Materials Storage Yard (RMSY), ER Site 43

Detected Chemical Analyte	95% Significance Distribution Type	Upper 95th Confidence Level Mean Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg)	Detected Analyte Status
Zinc	Normal	155	46.74	COPC
Americium-241	Lognormal[b]	0.066	ND	COPC
Cesium-137	Lognormal[c]	0.40	0.871	Analyte concentration is consistent with the background distribution
Plutonium-239/240[e]	Lognormal[a]	0.14	ND	COPC
Potassium-40	Lognormal[c]	20	25.34	Analyte concentration is consistent with the background distribution
Radium-226	Lognormal[c]	1.9	1.94	Analyte concentration is consistent with the background distribution
Tritium (H-3)	Lognormal	77.8[f]	ND	COPC
Thorium-232 (4n Decay Series)[g]	Lognormal[c]	1.1[h]	1.05	Analyte concentration is consistent with the background distribution
Uranium-235	Lognormal[a]	0.15[i]	0.168	Analyte concentration is consistent with the background distribution
Uranium-238 (4n+2 Decay Series)[j]	Lognormal[b]	0.6[k]	1.1	Analyte concentration is consistent with the background distribution

[a]Data set is greater than 50% censored. Lognormal distribution assumed.
[b]Distribution type could not be resolved at the 95% significance level. Lognormal distribution was assumed.
[c]Both normal and lognormal distribution types could not be rejected at the 95% significance level. Lognormal distribution was assumed.
[d]COPC = Contaminant of potential concern; analyte is retained for human health risk evaluation.
[e]Isotopes cannot be resolved using normal analytical methods; therefore, reported as plutonium-239/240.
[f]Tritium soil concentration derived from tritium soil moisture concentration.
[g]Thorium (4n) decay series progeny is assumed to be in secular equilibrium with thorium-232.
[h]Concentration of actinium-228 daughter, assumed to be in secular equilibrium with uranium-232.
[i]Highest detected soil concentration. Detection limit of U-235 assay was not available for this report.
[j]Uranium (4n+2) decay series progeny is assumed to be in secular equilibrium with uranium-238.
[k]Activity concentration derived from total uranium value, assuming all detected uranium is the uranium-238 isotope.
ND = Background concentrations for this analyte have not been defined in SNL/NM soils at this time.

For lognormally distributed analyte data sets, the 95% UCL was calculated as follows:

$$UCL_{95\%} = \exp\left(\mu + 0.5s^2 + \frac{s \cdot H_{95\%}}{(n-1)^{1/2}}\right)$$

where:

$UCL_{95\%}$ = upper confidence limit of the mean at the 95% significance level
μ = arithmetic mean of the transformed data set
$H_{95\%}$ = H-statistic at the 95% percent significance level for n samples (Gilbert 1987)
s = standard deviation of the transformed data set
n = number of samples

The representative site analyte soil concentrations were compared to background soil concentrations values obtained from the draft SNL/NM report "Background Concentrations of Constituents of Concern to the Sandia National Laboratories/New Mexico" (SNL 1994a). Analyte representative site soil concentrations which exceeded the background values were considered COPC. Analytes without defined background concentrations were also considered to be COPC. It should be noted that some analytes which are normally detected in environmental samples (e.g., cobalt, manganese, strontium, vanadium, etc.) were considered to be COPC because their respective backgrounds have not been defined at this time.

Analytes not normally considered toxic to humans at environmental concentrations (e.g., aluminum, iron, calcium, sodium, etc.) were excluded from being considered COPC. Table 2-1 summarizes the results of the COPC screening process.

2.3 Contaminants of Potential Concern

Three radionuclide analytes (americium-241, plutonium-239/240, and tritium [hydrogen-3]) and eight chemical analytes (chromium, cobalt, lead, manganese, strontium, titanium, and vanadium) were retained as COPC.

The thorium-232 representative concentration, as determined by the actinium-228 daughter activities, was similar to the SNL/NM background threshold level (1.1 pCi/g versus 1.05 pCi/g). The coefficient of variation (CV) of the thorium-232 data distribution, defined as the standard deviation divided by the mean, was less than 0.2 (i.e., 20 percent). Data sets with distributions containing outliers typically exhibit CV greater than 30 percent. This finding suggests that statistical outliers (i.e., "hot-spots") are not present within this data distribution. In addition, the RMSY thorium-232 representative soil concentration is similar to the average 1.2 pCi/g thorium-232 soil concentration value reported in the National Council on Radiation Protection and Measurements, Report Number 94, "Exposure of the Population in the United States and Canada from Natural Background Radiation" (NCRP 1987). Therefore, the thorium-232 data distribution was considered a high variant of the SNL/NM thorium-232 background and was removed from further COPC consideration in this HRA.

The data distributions for chromium, cobalt, manganese, strontium, and vanadium were also found to have a small CV (i.e., a CV less than 0.4). This result suggests that statistical outliers are not present and that these distributions may reflect a background distribution (chromium and lead were the only analytes with defined background soil concentrations). However, these analytes were considered COPC in this HRA because of the absence of corroborating evidence. Table 2-2 presents the final COPC list used in the RMSY HRA.

Table 2-2
Final Contaminants of Potential Concern (COPC) at the SNL/NM Radioactive Materials Storage Yard (RMSY)

Radionuclide COPC	Chemical COPC
Tritium (H-3)	Chromium
Americium-241	Cobalt
Plutonium-239/240	Lead
	Manganese
	Strontium
	Titanium
	Vanadium
	Zinc

3.0 Exposure/Risk Assessment

The exposure assessment of the RMSY HRA for radionuclide COPCs was performed using the SNL/NM *Précis*, Version 1.0 computer program (SNL 1994b). Précis estimates the annual dose rate received by a human receptor who is exposed to the COPC soil concentrations through direct interactions at the RMSY. The Précis results are assumed to represent the dose rate to a "reasonably maximally exposed" (RME) individual. This approach is conservative because the average dose rate to off-site receptors would be significantly less due to dilutional effects of contaminant transport mechanisms.

The Précis computer program does not have the capability to evaluate exposure/risk rates from the chemical COPC at the time of this HRA. The RMSY HRA for chemical COPC was performed using the EPA RAGS document as guidance. RAGS also estimates exposures/risks using the RME technique and is considered a conservative approach.

3.1 Radionuclide COPC Exposure Evaluation

3.1.1 Identification of Exposure Pathways

The residential/farming scenario and the industrial scenario were used to evaluate radionuclide COPC exposures in the RMSY HRA. The residential/farming scenario, evaluated using the *Précis* program, makes the following exposure assumptions:

- The individual establishes a residence at the evaluated site.
- The individual consumes drinking water from a well drilled directly through the evaluated site.
- The individual consumes vegetable and fruit products grown in the soils at the evaluated site.
- The individual consumes meat and dairy products from animals which have been exposed to forage and ground water produced at the evaluated site.

The industrial scenario makes the following exposure assumptions:

- The individual works at the evaluated site only.
- The individual does not mitigate his potential exposures by avoiding contaminant contact or using personal protective equipment (i.e., individual is unaware of the existence of hazards).
- The individual consumes drinking water from a well drilled directly through the evaluated site.

The scenario parameters are conservatively biased to yield the maximum RME individual dose estimation. Any deviation from these assumptions is expected to decrease the RME individual dose estimate. The inhalation (i.e., fugitive dust inhalation), ingestion (i.e., soil, water, and plant and animal products ingestion), and external radiation exposure pathways were evaluated in the two scenarios as displayed in Figure 3-1.

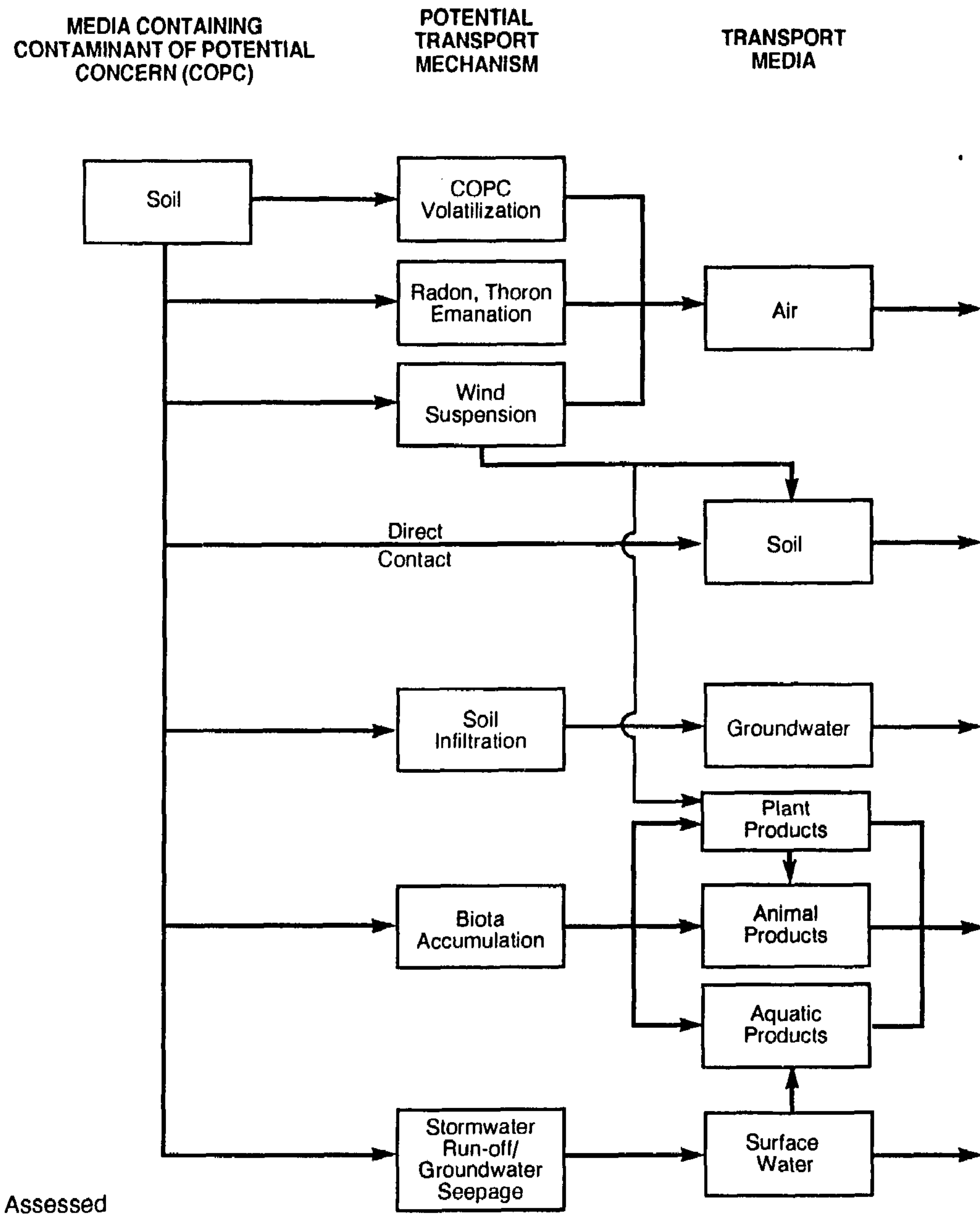
The *Précis* program has the capability to project the annual dose rates for future years. Applicable federal regulations (i.e., DOE and EPA) do not specify time intervals for future compliance assessments. In lieu of regulatory guidance, the maximum future time projection was limited to 500 years (i.e., year 2494). It should be noted that, as for all time projections, the reliability of the *Précis* program results strongly decreases with increasing projection time.

3.1.2 Determination of RME Dose Rates

Précis determines an individual's annual dose rate using a probabilistic (stochastic) technique. This stochastic technique provides a realistic estimate of the dose rate from future exposures by recognizing that program input parameters are not discrete, non-stochastic values. These input parameters are stochastic variables which reflect the potential temporal variabilities of the RME individual's contact with COPC and the uncertainties of the input parameters used in the *Précis* program. *Précis* evaluates this variability using a Latin-Hypercube sampling technique which evaluates the entire range of the parameter with its probability distribution. The resulting *Précis* output provides a stochastic presentation of the individual's annual dose rate which includes the most probable annual dose rate, as well as the RME individual dose rate.

A sensitivity analysis of the *Précis* input parameters was performed to determine which of the parameters influenced the final annual dose rate output. The sensitivity analysis is performed internally by the *Précis* program by systematically varying each input parameter by one percent while keeping all other parameters constant. Parameters were considered "supra-linear" if they altered the *Précis* output by more than one percent, "linear" when the output was changed by approximately one percent, and "sub-linear" when the output was altered by less than one percent. Parameters which did not effect the final output by more 0.01 percent were considered non-sensitive in this HRA. The sensitivity analysis was repeated using parameters which emphasized and de-emphasized the water infiltration pathways at the RMSY. Appendix B contains the *Précis* sensitivity analysis output files and Table 3-1 summarizes the results of the RMSY sensitivity analysis.

Probability distributions were then obtained, or developed, for the sensitive *Précis* input parameters. The distributions were obtained from known site-specific parameter ranges (e.g., 301462.65.03/ltd A2



ROUTE	RECEPTOR			
	HUMAN			
COPC Type	Radionuclide		Chemical	
Exposure Scenario	Residential	Occupational	Residential	Occupational
Inhalation	S	S	D	D
Dermal	—	—	—	—
External Radiation	—	—	N/A	N/A
Ingestion	S	S	D	D
Dermal	—	—	—	—
External Radiation	S	S	N/A	N/A
Ingestion	S	S	—	—
Inhalation	—	—	—	—
Dermal	—	—	—	—
External Radiation	—	—		
Ingestion	S	—	—	—
Dermal	—	—	—	—
External Radiation	—	—	N/A	N/A
Ingestion	—	—	—	—
Inhalation	—	—	—	—
Dermal	—	—	—	—
External Radiation	—	—	N/A	N/A

— Pathway not Assessed

S Stochastic Evaluation of this Pathway

D Deterministic Evaluation of this Pathway

N/A Not Applicable

Figure 3-1
Exposure Pathway Model Used to Evaluate the Radioactive Materials Storage Yard (RMSY), ER Site #43

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5/18/94

Table 3-1

Summary of SNL/NM Radioactive Materials Storage Yard (RMSY) Précis Sensitivity Analysis Results and Stochastic Input Parameters

Précis Input Parameter	Sensitivity Response	Distribution Type	Distribution Range	
			0.1%	99.9%
Contaminated zone area (m^2)	Linear	Constant[a]	NA	NA
Leafy vegetable intake (kg/yr)	Sublinear	Lognormal[b]	Residential: 0.66	33
			Industrial: NA	NA
Fraction of time indoors	Sublinear	Constant[c]	NA	NA
Occupancy and shielding factor	Sublinear	Constant[c]	NA	NA
Inhalation occupancy factor	Linear	Constant[c]	NA	NA
Fraction of time outdoors	Sublinear	Constant[c]	NA	NA
Inhalation rate (m^3/yr)	Linear	Normal[b]	Residential: 3,725	7,075
			Industrial: 3,049	5,051
Dust dilution length (m)	Sublinear	Uniform	1	10
Air mass loading factor (g/m^3)	Linear	Uniform	2E-05	0.002
Soil ingestion rate (g/yr)	Sublinear	Lognormal[b]	Residential: 0.31	15.6
			Industrial: 0.12	20.5
Thickness of contaminated zone (m)	Supralinear	Uniform	0.5	1.5
Contaminated Zone B factor	Supralinear	Lognormal	0.4	10.3
Contaminated zone density (g/cm^3)	Supralinear	Uniform	1.36	1.68
Contaminated zone hydraulic conductivity (m/yr)	Linear	Lognormal	1.8	11,000
Contaminated zone total porosity	Supralinear	Uniform	0.25	0.4
Precipitation rate (m/yr)	Sublinear	Lognormal	0.0002	0.01
Americium-241 soil concentration (pCi/g)	Sublinear	Lognormal	0.014	0.23
Americium-241 Kd factor—contamination zone	Sublinear	Uniform	0.001	5
Plutonium-239/240 soil concentration (pCi/g)	Linear	Lognormal	0.008	0.435
Plutonium-239/240 Kd factor	Supralinear	Uniform	0.001	1,000
Drinking water intake (L/yr)	Nonsensitive	Lognormal[b]	Residential: 20.5	1,005
			Industrial: 42.9	1,355
Unsaturated Zone B factor	Nonsensitive	Lognormal	0.4	10.3
Saturated Zone B factor	Nonsensitive	Lognormal	0.4	10.3
Thickness of unsaturated zone (m)	Nonsensitive	Uniform	125	150
Unsaturated zone hydraulic conductivity (m/yr)	Nonsensitive	Lognormal	1.8	11,000

Refer to footnotes at end of table.

Table 3-1 *(Continued)*

Summary of SNL/NM Radioactive Materials Storage Yard (RMSY) Précis Sensitivity Analysis Results and Stochastic Input Parameters

Précis Input Parameter	Sensitivity Response	Distribution Type	Distribution Range	
			0.1%	99.9%
Saturated zone hydraulic conductivity (m/yr)	Nonsensitive	Lognormal	1.8	11,000
Americium-241 Kd factor—Unsaturated zone	Nonsensitive	Uniform	0.001	5
Americium-241 Kd factor—Saturated zone	Nonsensitive	Uniform	0.001	5
Tritium soil concentration (pCi/g)	Nonsensitive	Lognormal	0.0002	0.842
Plutonium-239/240 Kd factor—Unsaturated zone	Nonsensitive	Uniform	0.001	1,000
Plutonium-239/240 Kd factor—Saturated zone	Nonsensitive	Uniform	0.001	1,000

[a]Parameter is a known constant.
[b]Parameter distribution derived using Crystal Ball.
[c]Default parameter used.
NA = Not applicable.

hydrological, geological, and precipitation variances), known exposure parameter ranges (e.g., receptor water, air, vegetation, and soil intakes), and known COPC soil concentration variances. Stochastic simulations using *Crystal ball*, Version 3.0 (Decisioneering Inc., 1993) were required to convert some of the probability distributions into the form required by *Précis*. Appendix C contains a summary of the *Crystal ball* simulations. Default *Précis* input parameters were used when probability distributions could not be obtained. The use of these default parameters is expected to provide a conservative bias to the *Précis* stochastic evaluation. Appendix D contains a summary of the *Précis* computer program input files.

3.1.3 Estimation of Dose Rate Associated With Each Pathway

Figures 3-2 through 3-8 summarize the *Précis* computed dose rates for human receptors at the RMSY under the residential/farming scenario. Figure 3-2 demonstrates that the maximum dose rate from all pathways from the radionuclide COPC at the RMSY is well below the 10 mrem/yr SNL/NM Action Level in the residential/farming scenario over the evaluated time interval. The dust inhalation pathway (Figure 3-3) was found to be the most significant pathway in the residential/farming scenario, followed by the vegetable ingestion pathway (Figure 3-6), external radiation exposure pathway (Figure 3-5), soil ingestion pathway (Figure 3-4), meat ingestion pathway (Figure 3-7), and the milk ingestion pathway (Figure 3-8). No dose rate was estimated from the water ingestion for any of the times

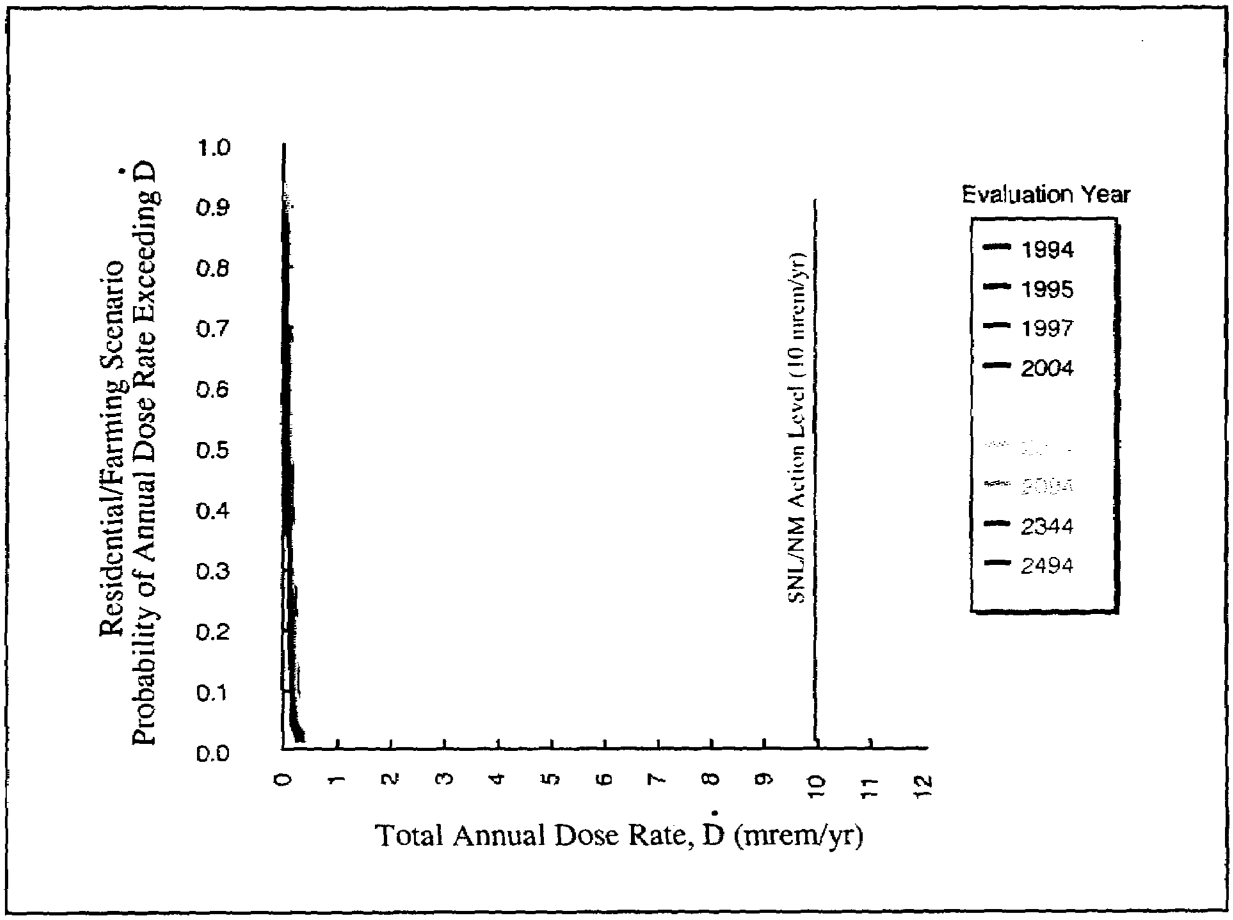

Figure 3-2
Total Dose Rate (All Pathways) versus Time, Residential/Farming Scenario
SNL/NM Radioactive Materials Storage Yard (RMSY)

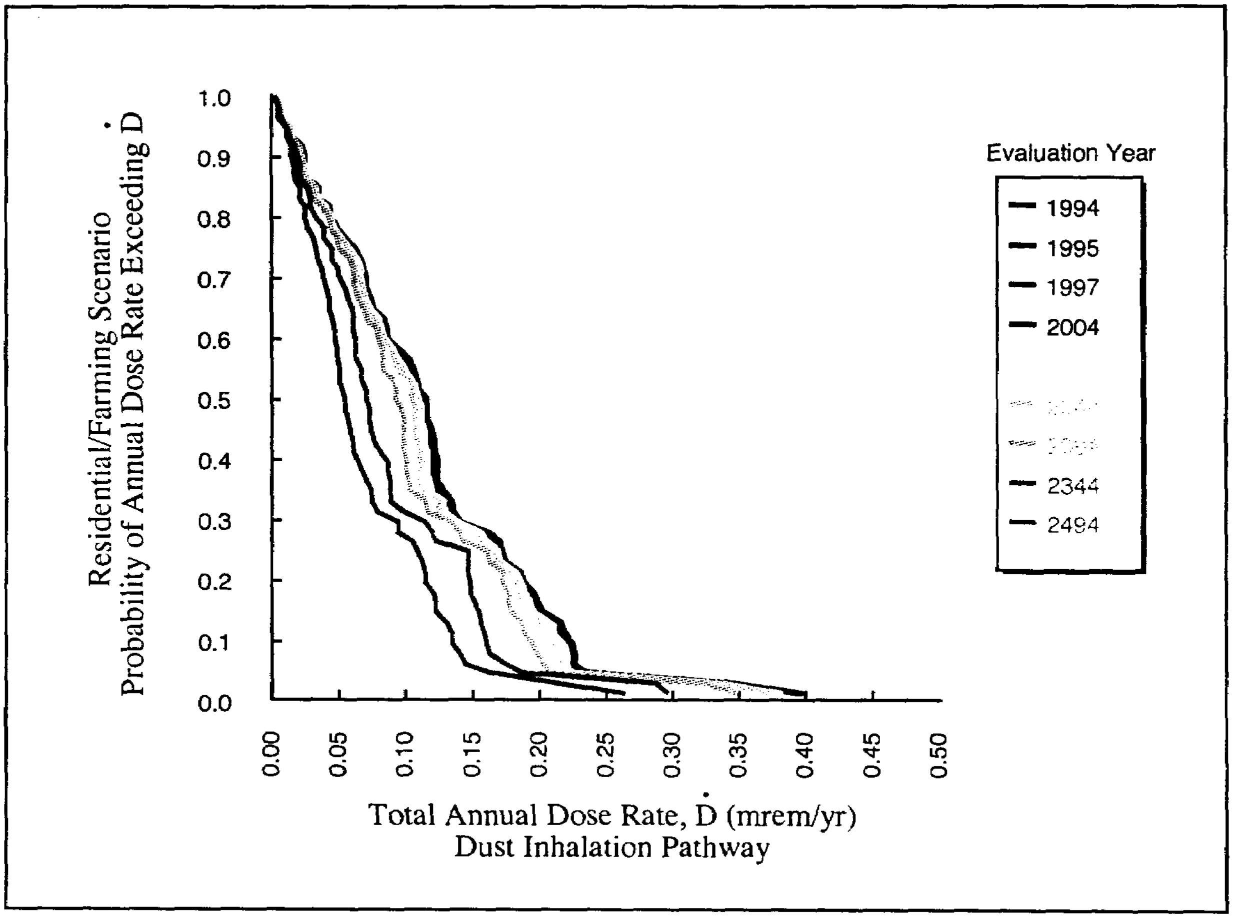

Figure 3-3

Dust Inhalation Pathway Dose Rate versus Time, Residential/Farming Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

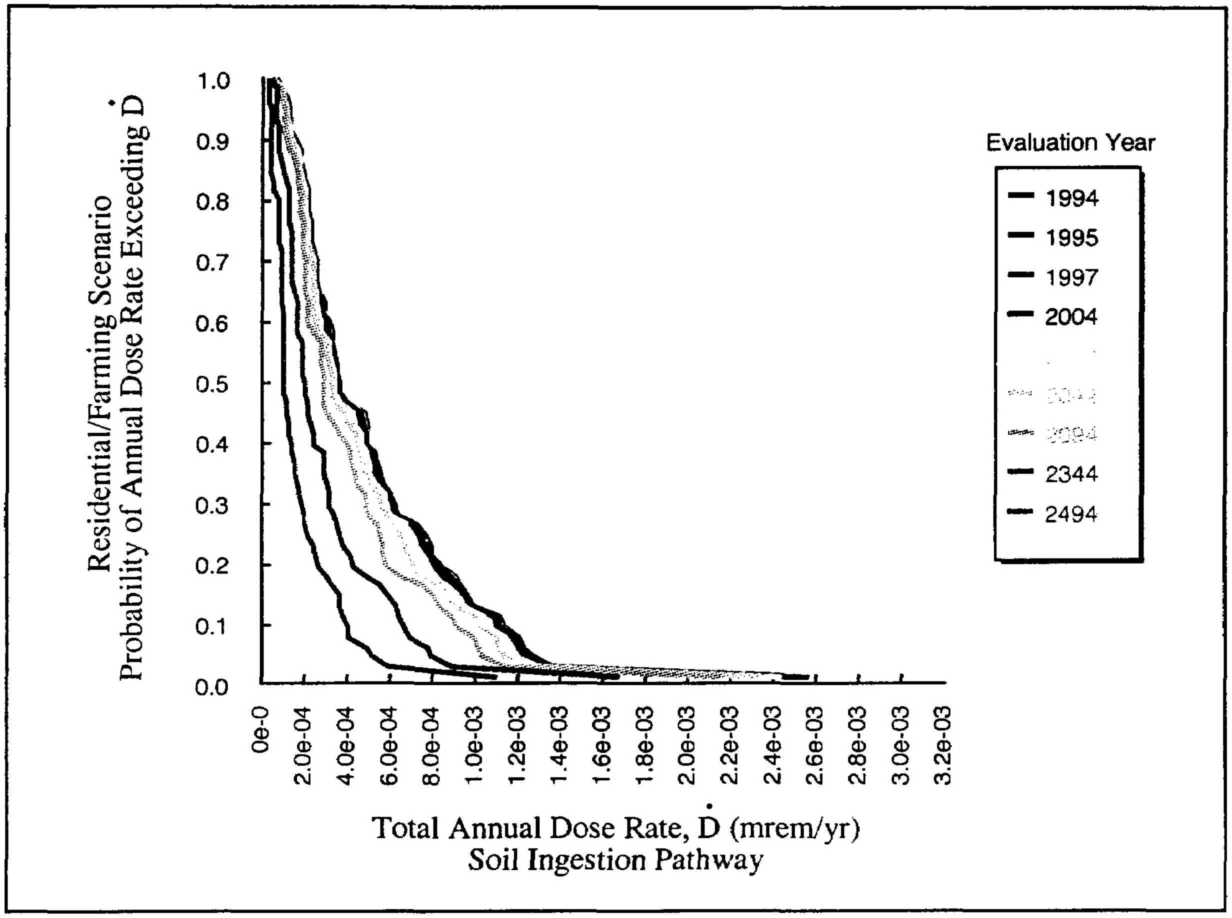

Figure 3-4

Soil Ingestion Pathway Dose Rate versus Time, Residential/Farming Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

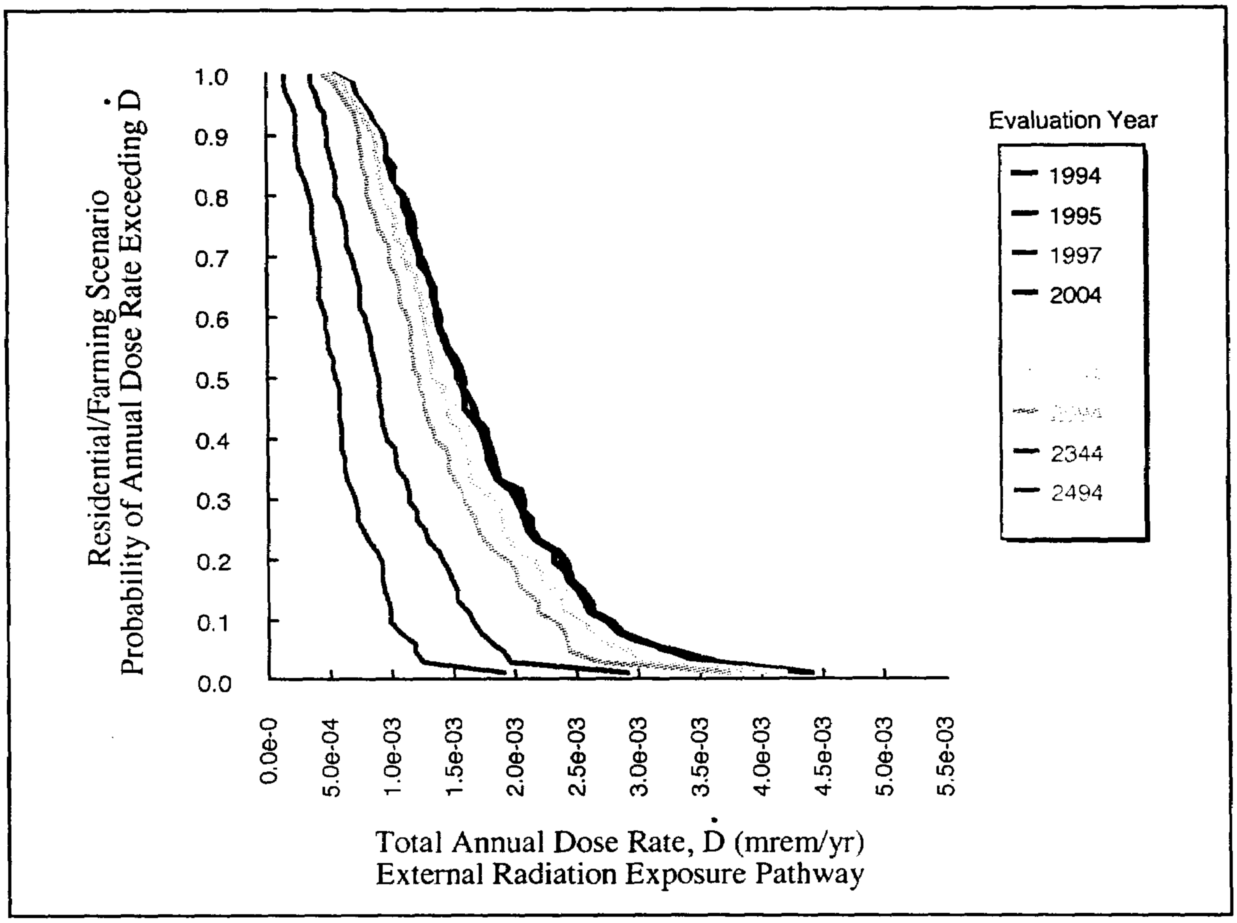

Figure 3-5

External Radiation Pathway Dose Rate versus Time, Residential/Farming Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

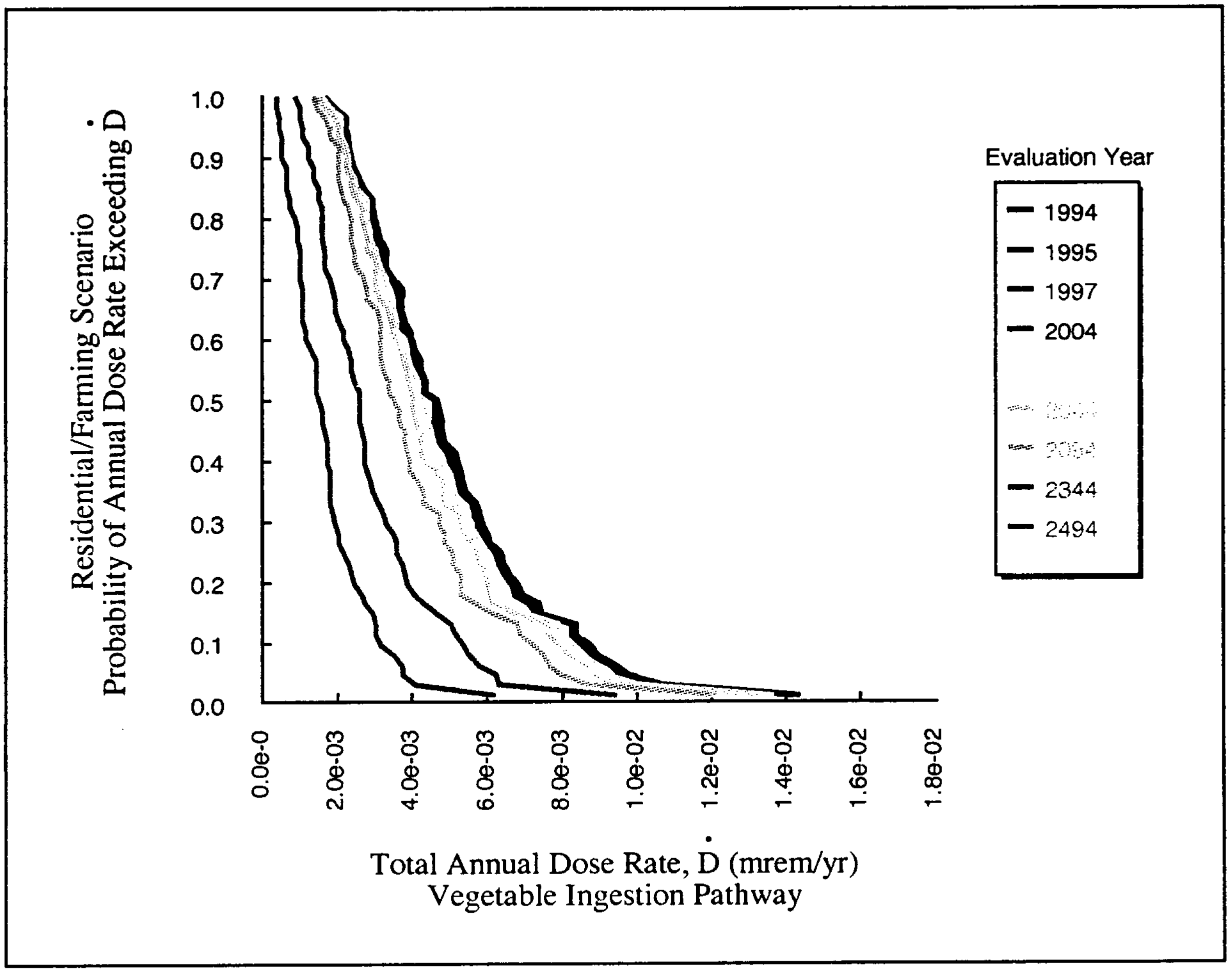

Figure 3-6

Vegetable Ingestion Pathway Dose Rate versus Time, Residential/Farming Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

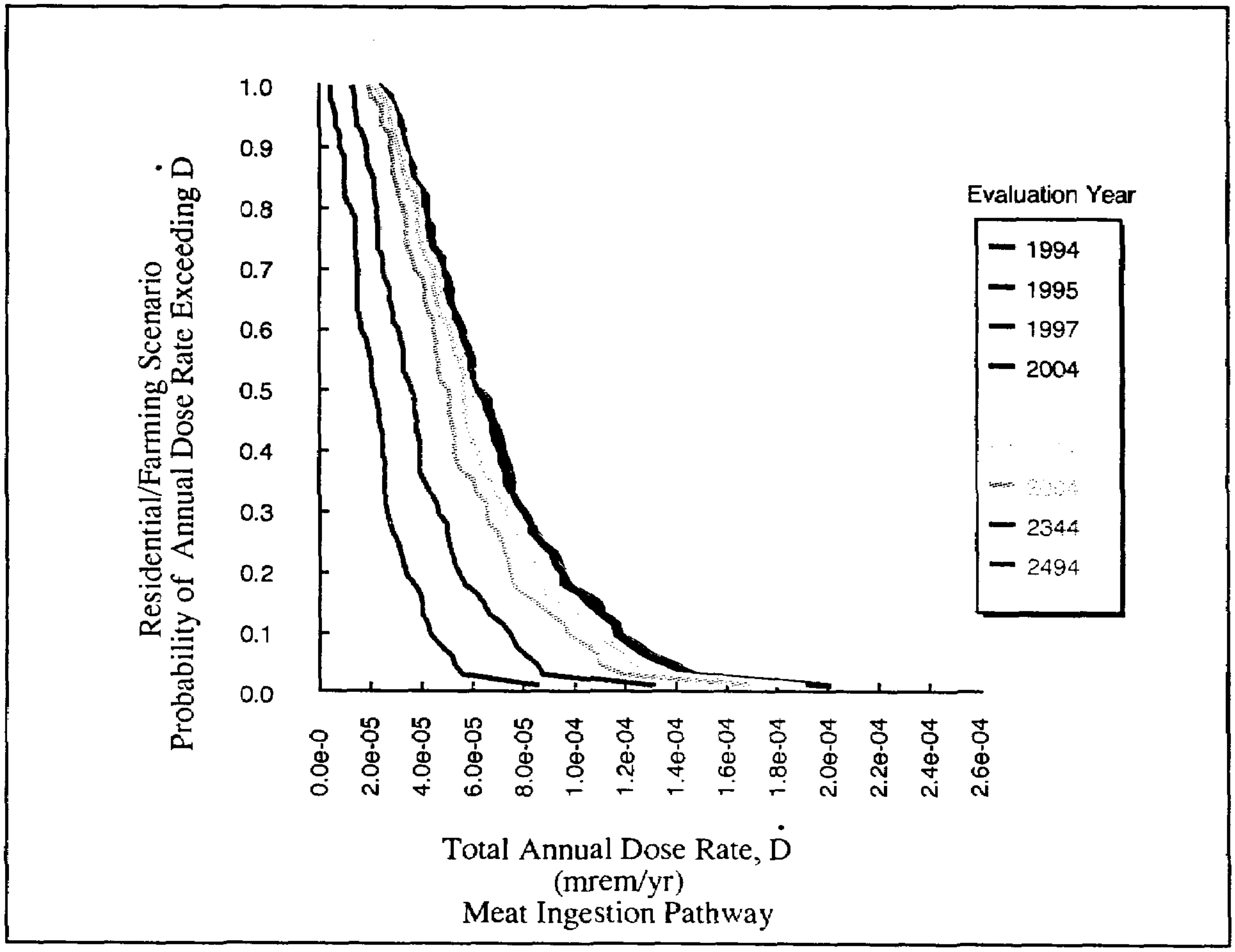

Figure 3-7

Meat Ingestion Dose Rate versus Time, Residential/Farming Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

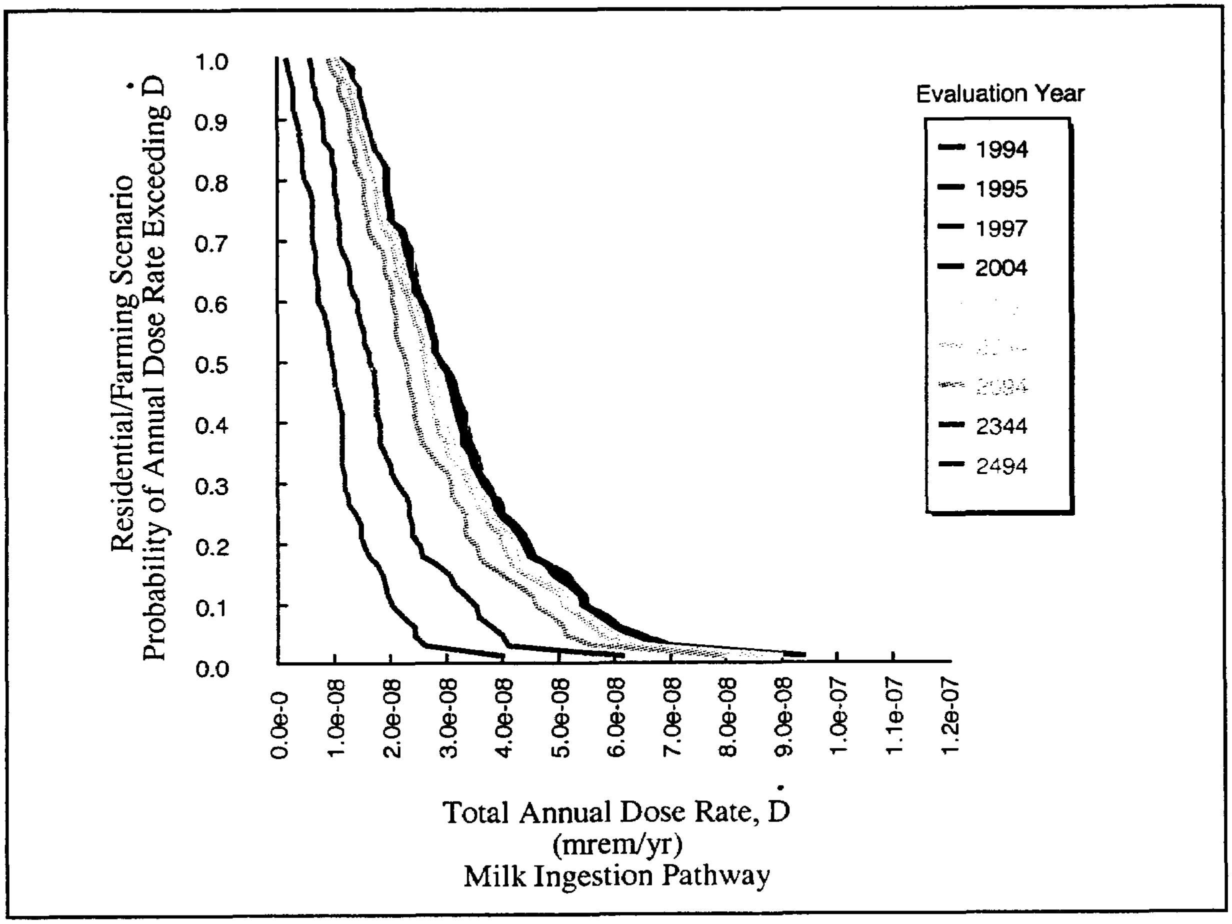

Figure 3-8

Milk Ingestion Dose Rate versus Time, Residential/Farming Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

evaluated. This suggests that the radionuclide COPC have no effect on ground water quality within the 500 year time frame evaluated.

Figures 3-9 through 3-11 summarizes the *Précis* computed dose rates for human receptors at the RMSY under the industrial scenario. Figure 3-9 demonstrates that the maximum dose rate from all pathways from the radionuclide COPC at the RMSY is well below the 10 mrem/yr SNL/NM Action Level in the industrial scenario over the evaluated time interval. The dust inhalation pathway (Figure 3-10) was found to be the most significant pathway in the industrial scenario, followed by the external radiation exposure pathway (Figure 3-11). Similarly to the residential/farming scenario, no dose rate was estimated from the water ingestion pathway. In addition, no significant dose rate was estimated from the soil ingestion pathway in the industrial scenario.

3.2 Chemical COPC Exposure Evaluation

3.2.1 Identification of Exposure Pathways

The residential scenario and the industrial scenario were used to evaluate chemical COPC exposures in the RMSY HRA. It should be noted that the number of pathways evaluated under the EPA RAGS methodology is not as extensive as the *Précis* evaluation (i.e., drinking water pathway is not evaluated) in both scenarios (Figure 3-1). Future versions of the *Précis* program will evaluate chemical COPC in the same manner as radionuclide COPC. The residential scenario makes the following exposure assumptions:

- The individual establishes a residence at the evaluated site.

The industrial scenario makes the following exposure assumptions:

- The individual works at the evaluated site only.
- The individual does not mitigate his potential exposures by avoiding contaminant contact or using personal protective equipment (i.e., individual is unaware of the existence of hazards).

Any deviations from these scenario assumptions is expected to decrease the RME individual's exposure from the RMSY COPC.

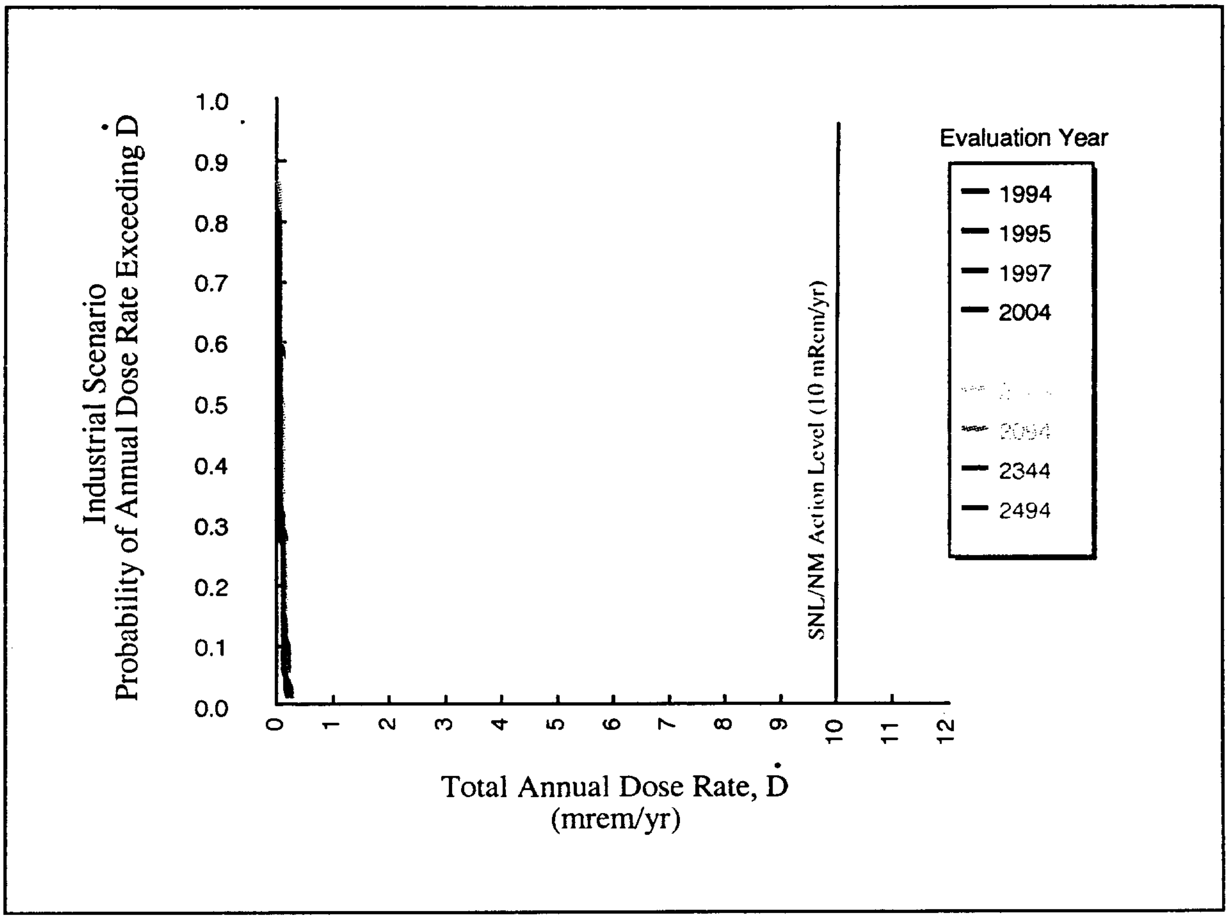

Figure 3-9

Total Dose Rate versus Time, Industrial Scenario
SNL/NM Radioactive Materials Storage Yard (RMSY)

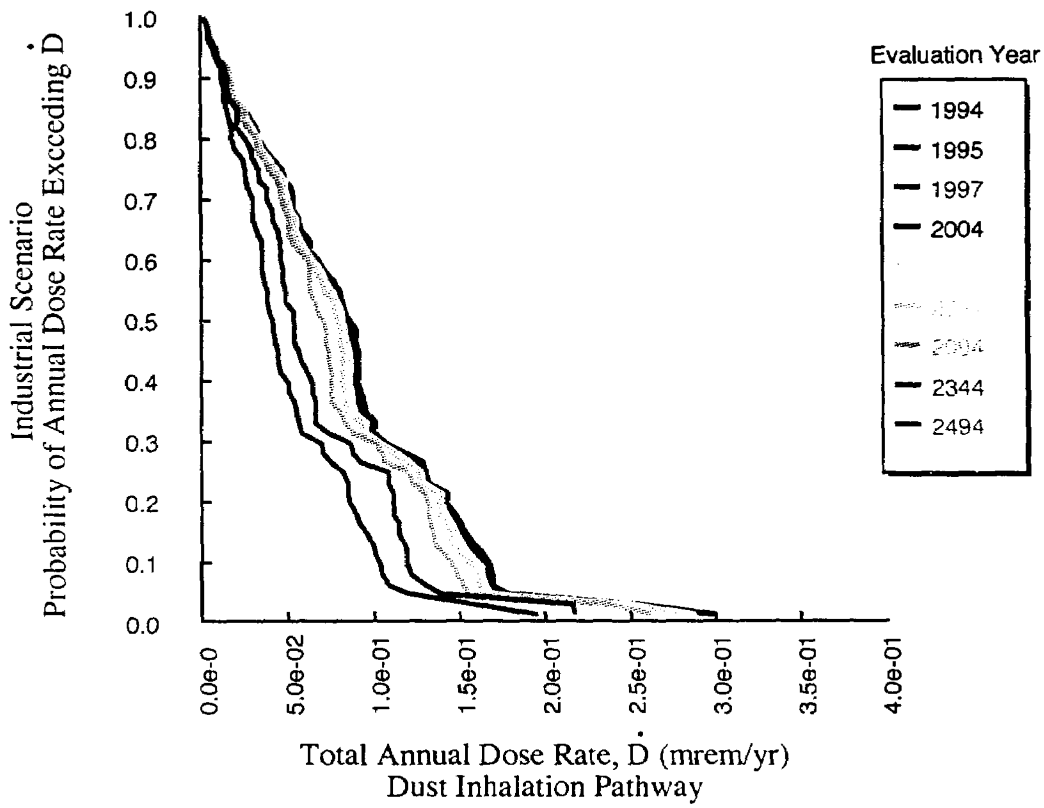

Figure 3-10

Dust Inhalation Pathway Dose Rate versus Time, Industrial Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

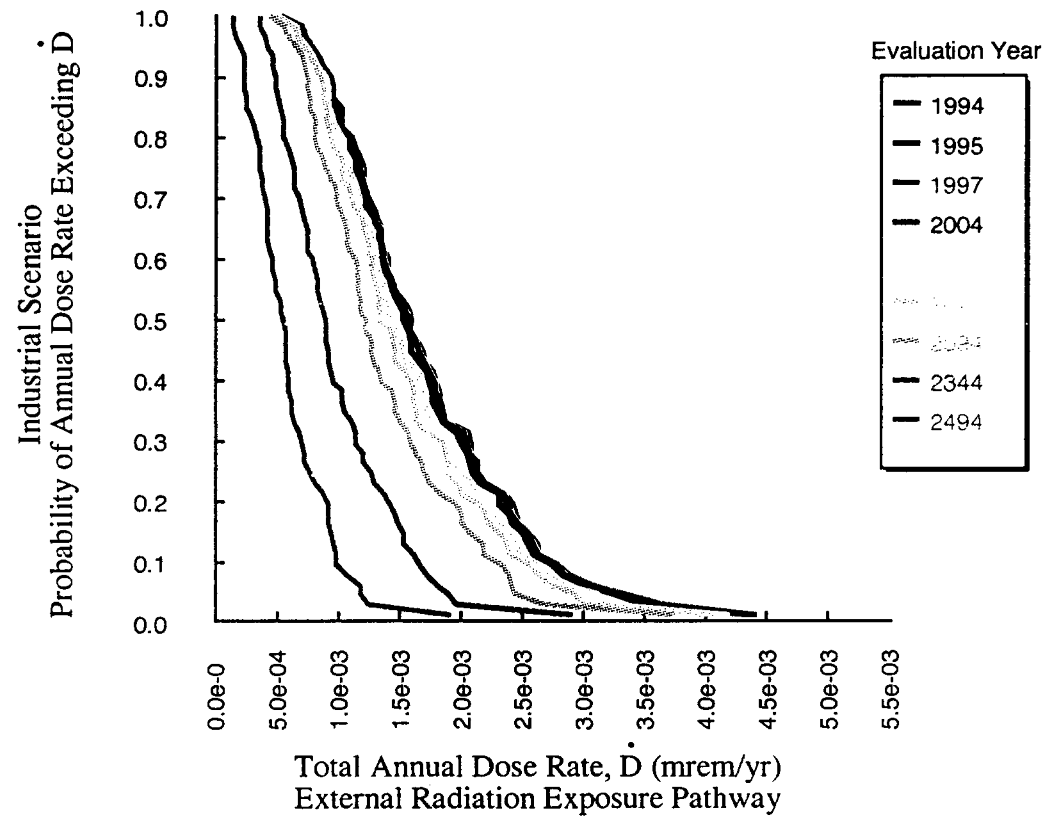

Figure 3-11

External Radiation Exposure Pathway Dose Rate versus Time, Industrial Scenario SNL/NM Radioactive Materials Storage Yard (RMSY)

3.2.2 Determination of RME Dose Rates

The RAGS methodology determines the exposure from chemical COPC at the RMSY using a deterministic (non-stochastic) approach. In contrast to *Précis*, the exposure parameters are constant values which reflect the upper-bound value of the possible range of values (EPA 1991). The conservatism of this approach is compounded by estimating the RME individual's exposure through a progression of upper-bound assumptions (e.g., the upper-bound value of time per day combined with the upper-bound value of days per year spent at the site, etc). The RME individual's dose rate from ingesting chemical COPC in soils was estimated using the following general equation (EPA 1989):

$$Intake = \frac{C \cdot IR \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

where:

Intake	= Contaminant-specific intake from soil ingestion (mg/kg-d)
C	= Soil concentration of the chemical COPC (mg/kg)
IR	= Soil Ingestion Rate (mg/d)
EF	= Exposure Frequency (d/yr)
ED	= Exposure Duration (yr)
CF	= Conversion Factor (10^{-6} kg/mg)
BW	= Body Weight (kg)
AT	= Averaging Time (yr x 365 d/yr)

Table 3-2 contains the standard EPA values for the soil ingestion pathway parameters used in this HRA (EPA 1991). Because the soil ingestion rates vary between adults and infants in the residential scenario, the soil ingestion dose rate was estimated using a variable exposure duration (i.e., 6 years of infant uptake, and 24 years of adult uptake). The industrial scenario involved only adult exposures.

The averaging time (AT) parameter is used to convert the total intake of the COPC into a daily intake rate. The length of the AT is dependent on the duration of the COPC adverse human health effect. Carcinogens are assumed to present a lifetime risk to the receptor, while systemic toxicants are assumed to result in adverse effects for the duration of exposure.

The RME individual's dose rate from inhaling dust containing chemical COPC originating from soils can be estimated using the following general equation (EPA 1989):

Table 3-2
Summary of SNL/NM Radioactive Materials Storage Yard (RMSY) Nonstochastic Exposure Parameters

EPA Default Parameter[a]	Residential Scenario	Industrial Scenario
Air Intake Rate	20 m^3/d	20 m^3/d
Soil Ingestion Rate	Adult: 100 mg/d Child: 200 mg/d	50 mg/d
Exposure Frequency	350 d/y	250 mg/d
Exposure Duration	Adult: 24 yr Child: 6 yr	25 yr
Body Weight	Adult: 70 kg Child: 16 kg	70 kg
Averaging Times	Carcinogen: 25,550 d Systemic toxicant: 10,950 d	Carcinogen: 25,550 d Systemic toxicant: 9,125 d

[a]Values obtained from the Supplemental Guidance for Standard Default Exposure Factors (EPA 1991).

$$Intake = \frac{C \cdot IR \cdot EF \cdot ED}{BW \cdot AT \cdot PEF}$$

where:

Intake = Contaminant-specific intake from dust inhalation (mg/kg-d)
C = Soil concentration of the chemical COPC (mg/kg)
IR = Air Inhalation Rate (m^3/d)
EF = Exposure Frequency (d/yr)
ED = Exposure Duration (yr)
BW = Body Weight (kg)
AT = Averaging Time (yr x 365 d/yr)
PEF = Particulate Emission Factor (m^3 /kg)

Table 3-2 contains the standard EPA values for the inhalation pathway parameters used in this HRA. The particulate emission factor (PEF) estimates the amount of soil which is suspended from wind movement. The PEF is dependent on a number of site-specific variables, such as wind speed, surface roughness, and vegetation profiles (EPA 1985), which were not available for the RMSY HRA. In lieu of this data, the EPA default PEF value of 4.63×10^9 m^3/kg was used in the RMSY HRA (EPA 1992b). The use of this value is considered conservative because it is representative of a surface with "unlimited erosion potential" which is characterized by a homogenous surface of finely divided materials with a large number of erodible particles (EPA 1992b). Heterogeneities present at the RMSY, such as variable particle sizes, vegetation and un-even surfaces, are expected to result in a less conservative PEF estimate which would result in a lower RME exposure.

3.2.3 Estimation of Dose Associated With Each Pathway

Chromium, in the Cr +6 valence state, is the only RMSY chemical COPC which is classified as a carcinogen by the EPA (EPA 1994). In lieu of specific data on the chromium valence state, all of the chromium detected in RMSY soils was conservatively assumed to be in the Cr +6 valence state. Table 3-3 contains the carcinogen intake estimated from Cr +6 exposure in the residential and industrial scenarios.

All of the chemical COPC, including chromium, were evaluated for potential systemic toxicant effects. Table 3-3 contains the systemic toxicant intakes estimated from the RMSY chemical COPC in the residential and industrial scenarios.

4.0 Toxicity Assessment of Chemical COPC

Hazardous materials are classified by their carcinogenic and systemic toxicity effects on human health. Systemic toxicity is described by the reference dose (RfD) concept (EPA 1989). The RfD is the estimate of daily exposure level for a human population, including sensitive subpopulations, that is likely to result in no adverse human health effect from chronic exposures. The RfD concept assumes that a threshold level exists for toxic effects. The RfD used in the RMSY HRA were obtained from the EPA Integrated Risk Information System (IRIS, EPA 1994). Table 4-1 contains the RfD for the RMSY systemic toxicant COPC.

Carcinogenicity is represented by slope factors (SF) that represent conservative estimates of the lifetime probability on an individual developing cancer from a chronic intake of the evaluated carcinogen (EPA 1993). The SF assumes that no threshold exists for carcinogenic probabilities. The SF used in the RMSY HRA was also obtained from IRIS and is presented in Table 4-1. Appendix E provides a brief toxicity profile of each of the RMSY COPC.

Table 3-3

Intakes of Chemical Contaminants of Potential Concern (COPC) SNL/NM Radioactive Materials Storage Yard (RMSY)

Carcinogenic Chemical COPC	95% Upper Confidence Level Mean Soil Concentration (mg/kg)	Residential Scenario		Industrial Scenario	
		Ingestion Intake (mg/kg-d)	Inhalation Intake (mg/kg-d)	Ingestion Intake (mg/kg-d)	Inhalation Intake (mg/kg-d)
Chromium[a]	28	4.4E-05	7.1E-10	4.9E-06	4.2E-10

Systemic Toxicant COPC	95% Upper Confidence Level Mean Soil Concentration (mg/kg)	Residential Scenario		Industrial Scenario	
		Ingestion Intake (mg/kg-d)	Inhalation Intake (mg/kg-d)	Ingestion Intake (mg/kg-d)	Inhalation Intake (mg/kg-d)
Cobalt	5.1	1.8E-05	3.0E-10	2.5E-06	2.2E-10
Chromium	28	9.8E-05	1.7E-09	1.4E-05	1.2E-09
Lead	34	1.2E-04	2.0E-09	1.7E-05	1.4E-09
Manganese	230	8.0E-04	1.4E-08	1.1E-04	9.7E-09
Strontium	52	1.8E-04	3.1E-09	2.5E-05	2.2E-09
Titanium	690	2.4E-03	4.1E-08	3.4E-04	2.9E-08
Vanadium	32	1.1E-04	1.9E-09	1.6E-05	1.4E-09
Zinc	155	5.4E-04	9.2E-09	7.6E-05	6.6E-09

[a]Chromium assumed to be in the Cr+6 valence state.

Table 4-1

SNL/NM Radioactive Materials Storage Yard (RMSY) Chemical Contaminants of Potential Concern (COPC) Toxicity Parameters[a]

Chemical Carcinogen COPC	Ingestion Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$
Chromium[b]	—	42

Systemic Toxicant COPC	Ingestion Reference Dose (mg/kg-d)	Inhalation Reference Dose (mg/kg-d)
Cobalt	—	—
Chromium	5E-03	—
Lead	—	—
Manganese[c]	1.4E-01	1.1E-04
Strontium	6E-01	—
Titanium	—	—
Vanadium[d]	9E-03	—
Zinc	3E-01	—

[a]Toxicity Parameters obtained from the Integrated Risk Information System (IRIS, EPA 1994).
[b]Cancer slope factor for Cr+6.
[c]Reference dose for manganese in food.
[d]Reference dose for vanadium oxide.

5.0 Risk Characterization of Chemical COPC

The risk characterization combines the exposure and toxicity assessments into characterization terms which assist subsequent risk management decisions. For carcinogens, the risk is characterized by the incremental cancer risk (ICR) which is estimated as follows (EPA 1989):

$$ICR = Intake \cdot SF$$

where:

ICR = Contaminant-specific Lifetime Incremental Cancer Risk (dimensionless)
Intake = Intake Dose Rate (mg/kg-d)
SF = Contaminant-specific Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$

The ICR calculated by this methodology is considered conservative because the SF are based on the upper 95% confidence limit of the dose response curve (EPA 1989). Because carcinogenic effects are assumed to be additive, ICR from different contaminants and pathways were summed in the RMSY HRA.

Systemic toxic effects from contaminant exposures are evaluated by hazard quotients (HQ). The HQ represents the ratio of daily intake rates averaged over a specific exposure period to a contaminant-specific RfD. A HQ greater than one might indicate that an adverse toxic effect in humans would occur, especially in sensitive subpopulations. The HQ is estimated as follows (EPA 1989):

$$HQ = \frac{Intake}{RfD}$$

where:

HQ = Contaminant-specific Hazard Quotient (dimensionless)
Intake = Intake Dose Rate (mg/kg-d)
RfD = Contaminant-specific Reference Dose

HQ are assumed to be additive for systemic toxicants that effect the same target organ and operate by the same mechanism (EPA 1989). A conservative approach is to add all of the chemical-specific HQ from all exposure pathways to describe the total hazard index (HI) of the RMSY. If the HI exceeds unity, an evaluation of specific contaminant toxicities should be performed to ensure only substances with similar systemic toxicant effects are summed.

Table 5-1 displays the human health risk characterization of the RMSY. The total site ICR for the residential and industrial scenario resulting from chemical carcinogenic COPC (i.e., Cr +6) was estimated to be 3 x 10^{-8} (i.e., three cancer deaths per 100 million people exposed) and 2 x 10^{-8}, respectively. Because other valence states of chromium may exist and the estimates represent total cancer risk (i.e., risk from soil background is included), these ICR estimates are considered conservative. Both the residential and industrial scenario ICRs are less than 1 x 10^{-6} which has historically been regarded as the maximum acceptable ICR by the EPA.

HQ for the individual systemic toxicant COPC are tabulated in Table 5-1. The HI for the RMSY is estimated to be 0.04 in the residential scenario, and 0.006 in the industrial scenario. Both of scenario HI estimates are less than 1.0 which is the adverse human health effects threshold (i.e., HI less than 1.0 do not indicate adverse human health effects).

Lead was identified as a chemical COPC but could not be evaluated using the EPA RAGS methodology because the toxicity parameters were withdrawn from IRIS by the EPA. The EPA had determined that an RFD for lead is inappropriate because toxicological studies have not identified a toxic effect threshold value.

In lieu of toxicological parameters, the RMSY representative site concentration for lead was compared against the EPA OSWER Directive #9355.4-02. This interim guidance establishes a lead soil clean-up level for soil contamination at Superfund sites to be between 500 mg/kg and 1,000 mg/kg. The RMSY lead soil concentration (i.e., 34 mg/kg) constitutes only 7 percent of the more restrictive 500 mg/kg soil clean-up level.

6.0 Summary and Qualitative Uncertainty Discussion

Analyte concentrations detected in RMSY soils were compared with soil background values to determine the COPC evaluated in this HRA. Radionuclide COPC were evaluated on an annual dose rate basis using the SNL/NM *Précis* computer program. Chemical COPC were evaluated on a risk basis using the EPA RAGS methodology. COPC exposures were estimated for the residential and industrial scenarios. These scenarios are expected to provide

Table 5-1
SNL/NM Radioactive Materials Storage Yard (RMSY), ER Site 43 Human Health Risk Characterization

Chemical Carcinogen Contaminant of Potential Concern (COPC)	Residential (Nonfarming) Scenario			Industrial Scenario		
	Ingestion Incremental Cancer Risk (ICR)	Inhalation ICR	Total ICR[a]	Ingestion ICR	Inhalation ICR	Total ICR[a]
Chromium[b]	—	3.0E-08	3.0E-08	—	1.8E-08	1.8E-08
Site Totals[c]	—	3E-08	3E-08	—	2E-08	2E-08

Systemic Toxicant COPC	Residential (Nonfarming) Scenario			Industrial Scenario		
	Ingestion Hazard Index (HI)	Inhalation HI	Total HI[a]	Ingestion HI	Inhalation HI	Total HI[a]
Chromium[b]	2.0E-02	—	2.0E-02	2.7E-03	—	2.7E-03
Vanadium	1.2E-02	—	1.2E-02	1.7E-03	—	1.7E-03
Manganese	5.7E-03	1.2E-04	5.9E-03	8.0E-04	8.8E-05	8.9E-04
Zinc	1.8E-03	—	1.8E-03	2.5E-04	—	2.5E-04
Strontium	3.0E-04	—	3.0E-04	4.2E-05	—	4.2E-05
Cobalt	—	—	—	—	—	—
Lead	—	—	—	—	—	—
Titanium	—	—	—	—	—	—
Site Totals[c]	0.04	0.0001	0.04	0.006	0.00009	0.006

[a]Total COPC Lifetime Incremental Cancer Risk (ICR) or Hazard Index (HI) from all pathways.
[b]Risk characterization is based on most toxic chemical from this COPC.
[c]Total lifetime ICR or HI from all COPC over all pathways.
— = COPC does not present a risk or no toxicity data available for this pathway.

an upper bound of potential adverse human health effects from the RMSY COPC. Results of the RMSY HRA include:

- Annual dose rates are not expected to exceed 10 mrem/yr within the next 500 years from RMSY radionuclide COPC in the residential and industrial scenarios.

- Lifetime ICR from RMSY chemical COPC was not found to exceed 1 $x10^{-6}$ in the residential and industrial scenarios. ICR less than 1 x 10^{-6} have been historically regarded as acceptable by the EPA.

- RMSY site HI were found not to exceed the adverse human health effects threshold in the residential and industrial scenarios.

The results of this HRA are conditional estimates that reflect multiple assumptions and related uncertainties. These uncertainties must be discussed to provide the reader with a perspective that can be subsequently used in the risk management decision process. Uncertainty is associated with the data, exposure assessment, toxicity assessment, and risk characterization of the RMSY HRA.

Data uncertainty is associated with the appropriateness of the data used in the HRA. The data sets for two of the three radionuclide COPC, americium-241 and plutonium-239/240, were heavily censored (i.e., greater than 50% ND). Detected values from these data sets were assumed to represent significant results. A less conservative approach would evaluate these data sets for the presence of Type I measurement errors (i.e., false-positive results). Additional uncertainty is realized by assuming that data distributions with equivocal W test results were lognormal. These data uncertainties are expected to result in elevated dose/risk estimates.

Exposure assessment uncertainty is related to the appropriateness of the various exposure parameters and models used in the HRA. Several parameter distributions used in the *Précis* simulations were assigned uniform distributions which reflect a relative high degree of uncertainty. Additional site-specific information is required to develop more representative distributions which will reduce exposure assessment uncertainties. The EPA default parameters reflect conservative upper bound estimates. The uncertainty related to these parameters is systematically enhanced through each calculation in the RAGS methodology. These exposure assessment uncertainties are expected to add a conservative bias to the dose/ risk estimates (i.e., elevate dose/risk estimates).

Uncertainty is associated with the toxicity values and information used to assess potential adverse human health effects in this HRA. Appendix E provides a brief summary of the uncertainty inherent in the development of the toxicity values. Additional uncertainty is associated with assumptions regarding chemical/radionuclide forms of the RMSY COPC. These assumptions were:

- Detected chromium concentrations were assumed to be in the Cr +6 valence state.
- Detected plutonium-239/240 concentrations were assumed to be plutonium-240. Plutonium-240 is more hazardous to human health than plutonium-239.

Toxicity information for lead, cobalt, and titanium were not available (or removed by regulatory agencies) from the data sources used in this HRA. Uncertainty is associated with the unknown impact to human health from these COPC. These toxicity assessment uncertainties present an unknown impact on the risk estimates.

Risk characterization uncertainty is associated with derivation of the RMSY site HI. The HQ from multiple COPC over multiple pathways are assumed to be cumulative. This assumption of dose additivity is not always appropriate since these substances may have different effects in different target organs. In addition, the summation of individual HQ give equal weight to the critical effects of each COPC which may be of varying toxicological significance. This risk characterization assessment uncertainty is expected to result in elevated risk estimates.

These combined uncertainties served a useful purpose by providing a conservative-bias to the RMSY HRA. Reducing these uncertainties is expected to reduce the risk/dose estimates in the RMSY HRA.

7.0 References

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